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FINANCIAL RESILIENCE UNDER CLIMATE RISK: MODERATING EFFECTS OF ENVIRONMENTAL EXPOSURE ON PERFORMANCE OF AGRICULTURAL ENTERPRISES IN NIGERIA

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Abstract
This study investigates the moderating role of climate sensitivity on the relationship between firm-specific characteristics and financial performance among listed agricultural firms in Nigeria over the period 2014–2023. Using panel data from ten firms and employing a Generalized Least Squares (GLS) random effects model, the analysis explores how climate-related variations influence the impact of leverage, growth opportunity, complexity, liquidity, firm size, and firm age on return on assets. Results reveal that while climate sensitivity independently does not significantly influence financial performance, it significantly moderates the effect of liquidity on profitability, indicating heightened vulnerability to climatic shocks in firms with weaker liquidity profiles. The findings underscore the necessity for adaptive financial strategies in agribusiness, especially under Nigeria‘s climate volatility. The study contributes to the discourse on environmental-financial integration by offering empirical insights for policymakers, investors, and corporate managers in climate-sensitive economies. Limitations include the sectoral scope and data availability, with future research encouraged to explore multi-sectoral analyses and incorporate climate adaptation indices.

Keywords: Climate Sensitivity, Financial Performance, Agricultural Firms, Firm Characteristics, Panel Data, Nigeria
JELCodes:G32,Q54,M41,O55

1.0 Introduction

The agricultural sector plays a pivotal role in Nigeria's economic development, contributing significantlyto employment, food security, and gross domestic product (GDP). However, the sector remains highly susceptible to climate variability, which imposes substantial risks on firm performance and long-term sustainability (Akinyele & Sanusi, 2021). As climatic conditions become increasingly erratic due to global environmental changes, agricultural firms face heightened uncertainty in their operational environments, necessitating a deeper understanding of how internal firm characteristics interact with these external shocks. This study examines how climate sensitivity moderates the relationship between firm-specific attributes and financial performance in the Nigerian agricultural sector, focusing on a panelof ten listed firms over a ten-year period (2014-2023).

Traditional determinants of financial performance, such as firm size, leverage, growth opportunities, business complexity, liquidity, and firm age, have received substantialattention in the corporate finance literature (Chen et al., 2020; Al-Najjar & Hussainey, 2011). These firm-level factors are believed to shape strategic decisions, risk-taking behaviour, and ultimately profitability. However, the unique challenges posed by climate volatility, particularly for climate-sensitive sectors like agriculture, demand a more contextualised analysis. Integratingclimatesensitivityintofinancialperformancemodelsoffersanavenue to uncover hidden heterogeneities in firm resilience and adaptive capacity, especially in developing economies with weak institutional buffers (Onyekuru & Marchant, 2020).

The theoretical underpinning of this study is derived from the resource-based view (RBV)andcontingencytheory.TheRBVpositsthatfirmsachievesuperiorperformancethrough

strategic management of internal resources and capabilities (Barney, 1991). However, contingencytheorysuggests that firm success depends not onlyon internal configurations but also on the fit between internal attributes and external environments (Donaldson, 2001). Inthe context of Nigerian agricultural firms, climate sensitivity, manifested through rainfall variability, temperature fluctuations, and drought exposure, constitutes a significant external contingency that may alter the effect of internal characteristics on performance outcomes.

Despite the increasing relevance of climate risks, empirical investigations into its moderating effects remain scarce, particularly in the Nigerian context. While prior studies have explored the direct impact of environmental factors on firm performance (Liu et al., 2022; Issahaku et al., 2021), few have examined how these effects intersect with firm-level characteristics. Moreover, even fewer have employed composite climate sensitivity indices as formal moderators in firm performance models, thereby overlooking critical interaction effects that could inform risk mitigation and adaptation strategies.

Empirical literature emphasizes the multifaceted relationships between firm characteristics and financial performance, moderated by climate sensitivity and institutional factors. The bulk of these studies focus predominantly on developed economies or aggregate sectors, highlighting a critical research gap regarding the Nigerian agricultural sector's specific dynamics over the recent decade. This study addresses this gap by leveraging a climate sensitivity index (CSIX), constructed from rainfall and temperature variability data sourced fromtheNigerianMeteorologicalAgency(NIMET)andtheWorldBankClimatePortal,thus contributingnewinsights intohowclimatesensitivitymodulatestheserelationshipswithinan emerging market context.

Employing a Generalized Least Squares (GLS) Random Effects regression framework, the study analyses panel data from ten Nigerian agricultural firms listed on the Nigerian Exchange Group (NGX) over a ten-year period. The GLS method is preferred for its efficiency in handling unobserved heterogeneity and potential serial correlation in panel data (Baltagi, 2021). Results reveal that while climate sensitivity independently does not significantlyinfluence financial performance, it significantlymoderates the effect of liquidity on profitability, indicating heightened vulnerability to climatic shocks in firms with weaker liquidity profiles. The findings underscore the necessity for adaptive financial strategies in agribusiness, especially under Nigeria‘s climate volatility. It offers valuable insights for firm managers, policy makers, and investors aiming to improve climate resilience and sustainable profitability in Nigeria‘s vital but vulnerable agricultural sector.

This research contributes to the intersection of climate finance and corporate strategy by offering empirical evidence on how climate variability conditions the effects of internal firm attributes on financial performance. The remainder of the paper is structured as follows. Section 2 reviews relevant literature and theoretical foundations, Section 3 outlines the methodology and data sources, Section 4 present the results and discussion, and Section 5 concludes with policy implications, limitations, and recommendations for future research.

2.0 Literatureand Hypotheses

Understanding the relationship between firm characteristics and financial performance under varying climatic conditions necessitates a robust theoretical foundation. Two prominent frameworks - *the Resource-Based View (RBV) and Contingency Theory* - serve as the basis forthisstudy.Theseperspectivesenabletheincorporationofbothinternalfirmcapabilities

and external environmental dynamics such as climate sensitivity into the analysis ofcorporate performance. *RBV,* articulated by Barney (1991), posits that a firm's sustainable competitive advantage is primarily determined by the strategic deployment of valuable, rare, inimitable, and non-substitutable (VRIN) resources. Financial performance, within this context, reflects how effectively a firm can exploit its internal resources, such as financial leverage, managerial capability, operational liquidity, and innovation capacity. The RBV suggests that firms with superior resource configurations are better positioned to absorb shocks, adjust to environmental variability, and sustain profitabilityover time (Barney, 1991; Peteraf & Barney, 2003). In the agricultural sector, the ability to mobilize resources, such as capitalinvestment,croptechnology,andriskmanagementstrategies,iscrucialgiventhehigh dependence on ecological conditions.

RBV's internalist focus has been criticized for overlooking environmental dynamism (Priem &Butler, 2001). This limitation isaddressed by *Contingency Theory*, which asserts that there is no one-size-fits-all strategy for achieving high performance. Rather, optimal outcomes depend on the degree of fit between internal structures and external contingencies (Donaldson, 2001; Ginsberg & Venkatraman, 1985). In volatile environments, such as those affected by climate variability, firms must adapt their internal characteristics, complexity management,and governancemechanisms,toalignwithexternaluncertainties.Thistheoryis especially relevant in agricultural contexts where performance is frequently moderated by unpredictable weather patterns, drought risks, and seasonal volatility (Thornton et al., 2014).

Integrating these theories provides a comprehensive framework for analyzing the moderating role of climate sensitivity on the relationship between firm characteristics and financial performance. The RBV underscores the importance of internal resources, Contingency Theory highlights the need for alignment with environmental conditions, and Institutional Theory considers the broader socio-political context. This multi-theoretical approach enables a nuanced understanding of how Nigerian agricultural firms navigate the complexities of climate variability to maintain financial viability.

Recent literature has begun to explore the intersection of firm capabilities and environmental uncertainty. Hart and Dowell (2011) propose that firms with proactive environmental strategies, guided byboth internal competencies and contextual awareness, are more likelyto achieve long-term value creation. Tang and Tang (2012) show that firms facing environmental risk must develop adaptive capabilities such as scenario planning and supply chain diversification to sustain financial returns. The implication is that while firm characteristics matter, their impact on performance can be conditioned by the nature of the external environment, particularly climate sensitivity.

More contemporary studies have applied these frameworks to emerging markets. For example, Asongu and Odhiambo (2021) argue that firms in African countries often operate under institutional voids and environmental instability, where the effectiveness of internal strategiesis largelycontingent upon external factorssuchas regulatoryqualityand ecological stress. In the Nigerian context, Adesina and Ayinde (2023) emphasize that agricultural firms must notonlyinvestinproductionefficiencybutalsoaligntheirorganizationalpracticeswith climate-resilientstrategiestoensurefinancial sustainability.Theseinsights reinforcetheneed for an integrative theoretical approach that recognizes climate sensitivity as a significant moderator of the firm-performance relationship.

EmpiricalReview

Empiricalresearchontherelationshipbetweenfirmcharacteristicsandfinancialperformance has been extensive across various sectors, including agriculture. A consistent finding is that financial leverage, liquidity, firm size, and growth opportunities significantly influence firm profitability. For instance, studies by Chen et al. (2015) and Zhang and Li (2019) demonstrated that optimal leverage enhances financial performance by providing tax shields while excessive debt increases financial distress risks. Similarly, liquidity was found to havea dual role; while adequate liquidity supports operational efficiency (Delen et al., 2013), excessive liquidity may indicate underutilized resources (Kraus & Litzenberger, 1973; confirmed by recent empirical work by Smith & Wang, 2021).

Firm size is another robust determinant of financial performance, with larger firms benefiting from economies of scale, access to capital markets, and better risk absorption capacity (Majumdar, 1997; Adegbie et al., 2020). However, in highly volatile sectors like agriculture, some studies (e.g., Ogunleye et al., 2017; Alhassan & Dogbe, 2020) caution that size advantages may be offset by increased complexity and bureaucratic inertia, which could hinder rapid adaptation to environmental changes.

Growth opportunities, often proxied by market-to-book ratios, have been shown to positively correlate with firm performance in both developed and emerging markets (Chen & Steiner, 1999; Njoroge & Gathenya, 2021). These findings align with the signaling theory, where higher market valuation signals superior growth prospects that attract investments and improve firm outcomes (Ross, 1977). Nonetheless, in contexts characterized by climatic uncertainty, the realization of growth opportunities depends on the firm‘s ability to manage environmental risks (Adeoti et al., 2022).

Several empirical studies explicitly address the influence of climate sensitivity or environmental factors on firm performance. For example, Wang et al. (2022) used panel data to demonstrate that climate variability adversely affects agricultural productivity and firm profitability in East Asia. Similar findings were reported by Adeyemi and Ogunbiyi (2023), who highlighted that Nigerian agricultural firms exposed to erratic rainfall and temperature fluctuations experience significant financial stress, necessitating adaptive capacity.

Incorporating climate sensitivity as a moderating variable, recent studies underscore the conditional effects of firm characteristics on financial outcomes. Egbunike and Odum (2018) found that liquidity‘s positive effect on financial performance diminishes under high climate variability, implying firms require flexible financial management strategies. Likewise,Ezeohaet al. (2021)demonstratedthat the benefits offirm sizeon profitabilityarecontingent upon climate resilience capabilities, especially in sub-Saharan Africa‘s agricultural sector.

Other studies have explored regulatory and institutional pressures as factors influencing firm adaptation to climate risks. For example, NIMET (2022) and the World Bank (2023) reports emphasize the role of national climate policies and institutional frameworks in shaping firm strategies and performance outcomes. Empirical analyses byOkafor and Chukwu (2020) and Nwosu et al. (2024) support these assertions by showing that firms embedded in stronger institutional environments tend to invest more in climate adaptation, enhancing financial resilience. Mensah et al. (2021) synthesizing over 30 empirical papers highlighted that firms with proactive environmental management practices achieve better financial outcomes, particularlyinclimate-sensitivesectorssuchasagriculture.Thesefindingsalignwiththe

natural-resource-based view suggesting that sustainable resource management constitutes a strategic asset (Hart, 1995).

Hypotheses Development

Themoderatingroleofclimatesensitivityontherelationshipbetweenfirmfinancialstructure and performance is increasingly recognized in the literature. Financial leverage has been shown to influence firm profitability by balancing debt benefits and risks. However, environmental uncertainties, particularly climatic fluctuations, can exacerbate financial distress risks, altering the leverage-performance nexus. Empirical evidence suggests thatfirms with high exposure to climate variability may experience greater difficulty servicing debt obligations, potentiallyweakeningthepositiveimpact ofleverageon financial outcomes (Chen et al., 2015; Wang et al., 2022). Furthermore, studies highlight that climate-sensitive sectors require adaptive financial strategies to maintain performance amid environmental shocks (Adeyemi & Ogunbiyi, 2023; Ezeoha et al., 2021). Therefore, it is posited (as the paper‘s first null, **H1**) that the effect of financial leverage on firm performance issignificantly contingent upon the firm‘s climate sensitivity, implying a moderating influence of climatic conditions on this relationship.

Growth opportunities are fundamental drivers of firm profitability, with firms investing in new projects and market expansions typically exhibiting superior financial outcomes (Chen&Steiner, 1999; Njoroge &Gathenya, 2021). However, the realization of these opportunities in agriculture is particularly vulnerable to climatic risks such as unpredictable rainfallpatterns and temperature variability. Recent studies show that firms with high climate sensitivity face uncertainty in cash flows and project viability, which can constraininvestment decisions and undermine expected financial benefits (Adeoti et al., 2022; Mensah et al., 2021). This body of evidence suggests that climate sensitivity moderates the growth opportunity-performance linkage, potentially dampening the positive effects of expansion prospects under adverse environmental conditions. Consequently, the null is formulated (as the paper‘s second hypothesis, **H2**) that climate sensitivity significantly moderates the relationshipbetweengrowthopportunityandfinancialperformanceamongagricultural firms.

The complexity of business operations, often reflected in diversified product lines or extensive value chains, has mixed effects on financial performance. While complexity may allow risk diversification, it can also introduce managerial challenges and higher operational costs (Alhassan & Dogbe, 2020; Ogunleye et al., 2017). In climate-sensitive sectors, complexity may increase vulnerability to environmental shocks, as firms must manage multiple exposure points simultaneously (Nwosu et al., 2024). Evidence indicates that firms with complex operations in agriculture require robust climate adaptation mechanisms to sustain profitability (Okafor & Chukwu, 2020; Egbunike & Odum, 2018). Therefore, climate sensitivity is hypothesized (as the study‘s third null, **H3**) to significantly moderate the relationship between business complexity and financial performance, reflecting the conditional nature of complexity benefits under varying climatic stresses.

Liquidity, or the availability of readily accessible resources, is a critical determinant of firm performance,enablingfirmstomeetshort-termobligationsandinvestinopportunities(Delen et al., 2013; Smith & Wang, 2021). Nonetheless, excessive liquidity may signal inefficiency, especially in sectors where climate risk demands agile resource allocation (Egbunike & Odum,2018).Climatesensitivityimposesconstraintsoncashflowsandresourceavailability, influencingtheeffectivenessofliquiditymanagement(Adeyemi&Ogunbiyi,2023;Wanget

al., 2022). Therefore, it is anticipated (as the paper's fourth null, **H4**) that climate sensitivity significantly moderates the liquidity-performance relationship, impacting firms' ability to leverage liquid assets for optimal financial outcomes.

Firm size generally correlates positively with financial performance due to economies ofscale and market power (Majumdar, 1997; Adegbie et al., 2020). However, larger firms in climate-sensitive sectors may encounter heightened operational complexity and slower responsetimestoenvironmentalshocks,potentiallydiminishingthesizeadvantage(Alhassan & Dogbe, 2020; Ezeoha et al., 2021). Empirical evidence suggests that climate sensitivity introduces a boundary condition for the benefits of firm size, with adaptation capacityplaying a pivotal role (NIMET, 2022; Nwosu et al., 2024). The moderating effect of climate sensitivity on the size-performance relationship is hypothesized to be significant, being the study's fifth null, **H5**)

Lastly, the age of a firm is commonly associated with accumulated experience andestablished market presence, which positively affects financial performance (Majumdar, 1997; Adegbie et al., 2020). Nonetheless, older firms may exhibit organizational rigidity, limiting their adaptability to climate risks compared to younger, more flexible firms (Ogunleye et al., 2017; Ezeoha et al., 2021). Climate sensitivity can thus moderate the age- performance relationship by amplifying the need for dynamic adaptation capabilities, potentiallyconstraining older firms' performance under environmental stress. The hypothesis (**H6**)asserts that climate sensitivitysignificantlymoderatestheeffect offirmageon financial performance in agricultural firms.

3.0 Methodology

This study investigates the moderating role of climate sensitivity on the relationship between firm-specific characteristics and the financial performance of agricultural firms listed on the Nigerian Exchange Group. The analysis employs a balanced panel dataset comprising 10 firms over a ten-year period from 2014 to 2023. The use of firm-level panel data allows for the exploration of temporal and cross-sectional variations in financial dynamics, offering deeper insights into the idiosyncrasies of agricultural firms facing climate-related risks (Baltagi, 2021; Areal et al., 2022).

The data were extracted from a triangulation of sources, including firm annual reports, the NigerianMeteorological Agency(NIMET), andtheWorldBank ClimateChangeKnowledge Portal. Financial indicators such as return on assets, leverage, liquidity, growth opportunity, business complexity, firm size, and firm age were sourced from audited financial statements. Climate sensitivity was operationalized through a composite index combining normalized rainfall and temperature anomalies, a method consistent with recent climate-economic literature (Garnaut et al., 2020; Adeyemi et al., 2024).

The paper is theoretically found on the integration of RBV and Contingency Theory. Both provide a comprehensive lens for examining how internal firm characteristics, such as size, leverage, liquidity, and operational complexity, interact with climate variability to shape financial performance (Kraus & Litzenberger, 1973; Smith & Wang, 2021). This study contributes to this theoretical discourse by empirically testing these relationships within Nigerian agricultural firms, using climate sensitivity as a moderating variable. The expectation is that the strength and direction of firm characteristic-performance linkages will vary depending on firms' exposure and responsiveness to climatic risk.

The base model for this study draws upon a random effects panel regression framework, suitable for datasets where individual-specific effects are presumed uncorrelated with the regressors (Wooldridge, 2021). Following prior works (Baltagi, 2021; Greene, 2018), the baseline model without moderation is expressed as:

$$FIPE_{it}=\beta_0+\beta_1 FILE_{it}+\beta_2 GRFO_{it}+\beta_3 CMPB_{it}+\beta_4 LIQT_{it}+\beta_5 FSZE_{it}+\beta_6 FAGE_{it} +\beta_7 CSIX_{it}+\epsilon_{it} \quad (1)$$

Toassessmoderationbyclimatesensitivity,interactiontermswereintroduced:

$$FIPE_{it}=\beta_0+\beta_1 FILE_{it}+\beta_2 GRFO_{it}+\beta_3 CMPB_{it}+\beta_4 LIQT_{it}+\beta_5 FSZE_{it}+\beta_6 FAGE_{it}+\beta_7 CSIX_{it} +\beta_8(FILE_{it}\times CSIX_{it})+\beta_9(GRFO_{it}\times CSIX_{it})+\beta_{10}(CMPB_{it}\times CSIX_{it}) +\beta_{11}(LIQT_{it}\times CSIX_{it})+\beta_{12}(FSZE_{it}\times CSIX_{it})+\beta_{13}(FAGE_{it}\times CSIX_{it})+\epsilon_{it} \quad (2)$$

Table 1 shows the variable definitions and other information related to the variables. $FIPE_{it}$is the return on assets for firm $i$in year t, and ϵ_{it}denotes the idiosyncratic error term.Climate sensitivity ($CSIX$) enters as both a direct predictor and a moderator.

Each explanatory variable‘s expected relationship with financial performance is grounded in established theories. Financial leverage is expected to negatively influence performance due to higher interest obligations (Myers, 2001; Eze & Enekwe, 2022). Growth opportunity is anticipated to exert a positive effect, aligning with real options theory(Trigeorgis, 1996) and empirical findings from emerging markets (Idemudia et al., 2021).

Business complexity, captured by the number of subsidiaries, may have a non-linear relationship with performance, as excessive diversification can dilute strategic focus (Lawalet al., 2022). Liquidity is expected to positively affect firm performance, in line with the pecking order theory and empirical studies emphasizing liquidity as a buffer against risk (Ibrahim & Salihu, 2021). Firm size may yield either scale efficiencies or bureaucratic inefficiencies, thus its expected sign is ambiguous (Uwuigbe et al., 2021). Firm age is generally associated with greater market knowledge and brand equity, potentially enhancing performance (Ogundipe et al., 2020). Lastly, climate sensitivityis hypothesized to negatively affectperformanceduetoproductionvolatility, butitsinteractionwithfirm-levelfactorsmay yield conditional effects (World Bank, 2023).

The Generalized Least Squares (GLS) random effects estimator is applied, following a Hausman test ($\chi^2 = 6.385$, $p = 0.496$) which failed to reject the null hypothesis that individual effectsareuncorrelatedwithregressors,thusfavoringtherandomeffectsmodel(Wooldridge, 2021). The approach is appropriate and improves efficiency over fixed effects under these conditions (Wooldridge, 2010). In matrix notation, the GLS model is:

$$y=X\beta+\epsilon, \qquad \epsilon\sim N(0,\sigma^2 I_N \quad +\sigma_\epsilon^2 I_T \ ) \quad (3)$$

Where:yisthe$NT\times 1$vectorofoutcomes,Xisthe$NT\times k$matrixofexplanatory variables, βisa$k\times 1$vector ofparameters,ϵandconsistsofindividual andidiosyncraticerrors.

TheGLS estimatorcorrectsforserial correlation andheteroskedasticity, commoninfinancial panels (Greene, 2018). Multicollinearity was assessed using Variance Inflation Factors (VIFs), all below the threshold of 2 (Table 4), indicating acceptable levels (Kutner et al., 2005).Residualnormalitywastestedviathe Shapiro-Wilktest,whichindicatednon-

normality. As a robustness check, bootstrapped standard errors were applied to mitigate distributional assumptions (Cameron & Trivedi, 2010).

Table 1:
VariableMeasurement and Description

Variable	MeasurementDefinition	Expected Sign	References	Source
$FIPE_{i,t}$	$ROA=\frac{NetIncome}{TotalAssets}$		Fodioet al.(2020); Bakare et al. (2021); Okoye&Ofoegbu(2023)	Company AnnualReports
$FILE_{i,t}$	$\frac{TotalDebt}{Total\ Assets}$	–	Belloetal.(2020); Eze& Enekwe(2022);Yusuf& Bako (2023)	Company AnnualReports
$GRFO_{i,t}$	$\frac{MarketValueof\ Equity}{BookValueofEquity}$	+	Idemudia et al. (2021); Okereetal.(2022);Agbo et al.(2023)	NSEFactbook
$CMPB_{i,t}$	Number of segments/subsidiaries	±	Anyanwu & Okolo (2021);Lawaletal. (2022);Oyebanji& Akpan(2023)	Company AnnualReports
$LIQT_{i,t}$	$\frac{Current\ Assets}{CurrentLiabilities}$	+	Nwite et al. (2020); Ibrahim&Salihu(2021); Ugwu et al. (2023)	Company AnnualReports
$FSZE_{i,t}$	ln(TotalAssets)	±	Enekwe et al. (2020); Uwuigbeetal. (2021); Anihetal.(2023)	Company AnnualReports
$FAGE_{i,t}$	Numberofyearssince incorporation	+	Ogundipeetal.(2020); Ejike & Onoh (2022); Musa&Afolabi(2023)	Company AnnualReports
$CSIX_{i,t}$	Compositeindexofrainfall& temperature fluctuation	±	NIMET(2022);World Bank(2023);Adeyemiet al. (2024)	NIMET, World BankClimate Data

Source: Author (2024)

4.0 ResultsandImplications

The descriptive statistics in Table 2 highlight significant heterogeneity in firm characteristics across the Nigerian agricultural sector between 2014 and 2023. The average return on assets, a proxy for financial performance, was 8.7%, albeit with wide variability (SD = 17.2%), suggesting performance disparities likely influenced by firm-specific attributes and external shocks, such as climate variability. Firm leverage averaged 16.3%, implying a generally conservativecapitalstructure,whilegrowthopportunitiesvarieddrastically(mean=1.78;SD = 11.13), indicating investor uncertainty or speculative valuations. The climate sensitivity index (mean = 0.241) reflects mild-to-moderate exposure to climate anomalies, which is critical for agricultural productivity in Nigeria (Nwosu et al., 2023; World Bank, 2023).

Table 3 reveals modest correlation among the variables, with firm size negatively associated with performance at the 5% level, while firm age and complexity show weak or statistically insignificant relationships. Notably, climate sensitivity displayed moderate negative correlation with firm size, supporting the notion that larger firms may be less vulnerable due todiversificationoradaptationinvestments(Adeyemietal.,2024).Theabsenceofsevere

multicollinearity is confirmed in Table 4, as all VIF values remained below 2, and the Shapiro-Wilk test flagged non-normality in most variables, justifying the use of GLS estimationtocorrectforheteroscedasticityandotherpanel-relateddistortions(Baltagi,2021). The Hausman specification test (Table 5) supports the random effects model (p = 0.496), validating the assumption that firm-specific effects are uncorrelated with the regressors. This choice aligns with prior studies on heterogeneous Nigerian firms using unbalanced panels (Bakare et al., 2021; Ogundipe et al., 2022).

Table 2:
DescriptiveStatistics

Variable	Mean	Std. Dev.	Min	Max
$FIPE_{i,t}$	0.087	0.172	-0.247	0.771
$FILE_{i,t}$	0.163	0.129	0.000	0.510
$GRFO_{i,t}$	1.780	11.126	-0.981	78.399
$CMPB_{i,t}$	3.660	2.429	0.000	11.000
$LIQT_{i,t}$	0.926	1.360	0.139	10.057
$FSZE_{i,t}$	7.614	0.424	6.395	9.116
$FAGE_{i,t}$	26.500	7.046	15.000	41.000
$CSIX_{i,t}$	0.241	0.219	0.000	0.881

Source: Author (2024).

Table 3:
PairwiseCorrelation Matrix

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
(1) $FIPE_{i,t}$	1.000							
(2) $FILE_{i,t}$	-0.037	1.000						
	(0.800)							
(3) $GRFO_{i,t}$	-0.040	0.229	1.000					
	(0.780)	(0.109)						
(4) $CMPB_{i,t}$	0.042	0.141	0.015	1.000				
	(0.774)	(0.330)	(0.915)					
(5) $LIQT_{i,t}$	-0.063	-0.114	-0.062	-0.065	1.000			
	(0.666)	(0.432)	(0.668)	(0.656)				
(6) $FSZE_{i,t}$	-0.279*	-0.009	-0.196	0.214	-0.074	1.000		
	(0.050)	(0.949)	(0.172)	(0.136)	(0.611)			
(7) $FAGE_{i,t}$	-0.038	0.358**	-0.105	0.375**	0.008	0.276*	1.000	
	(0.791)	(0.011)	(0.469)	(0.007)	(0.957)	(0.052)		
(8) $CSIX_{i,t}$	0.235	-0.223	0.147	0.124	-0.182	-0.303**	-0.074	1.000
	(0.101)	(0.120)	(0.307)	(0.390)	(0.206)	(0.033)	(0.608)	

Source: Author (2024).

Table 4:
Shapiro-WilkNormality andVarianceInflationFactor(VIF)MulticollinearityTest

Variable	Shapiro-WilkW	z-value	Prob>z	VIF	1/VIF

Variable	Shapiro-WilkW	z-value	Prob>z	VIF	1/VIF
$FIPE_{i,t}$	0.754	11.566	0.000	—	—
$FILE_{i,t}$	0.934	3.085	0.008	1.460	0.687
$GRFO_{i,t}$	0.175	38.807	0.000	1.440	0.694
$CMPB_{i,t}$	0.906	4.422	0.001	1.370	0.732
$LIQT_{i,t}$	0.307	32.585	0.000	1.330	0.751
$FSZE_{i,t}$	0.853	6.927	0.000	1.250	0.801
$FAGE_{i,t}$	0.965	1.655	0.141	1.170	0.858
$CSIX_{i,t}$	0.892	5.085	0.000	1.100	0.909

Source: Author (2024).

Table 5:
HausmanSpecificationTest(FixedEffectsvs.RandomEffects)

TestStatistic	Value
Chi-squareteststatistic	6.385
p-value	0.496

Source: Author (2024).

Table 6 presents the main effects estimation. Only growth opportunity and firm size show marginal significance, both negatively associated with financial performance at the 10%level. Contrary to expectations, the negative effect of growth opportunity implies possible inefficiencies in capital allocation or weak investor confidence, while larger firms may suffer diseconomies of scale or rigidity in adapting to external shocks (Okere et al., 2022; Lawal et al., 2022). Climate sensitivity, as a direct predictor, was statistically insignificant, suggesting that its impact may operate through interactions with firm-specific characteristics.

The interactionmodelinTable7significantlyenhancestheexplanatorypower(R^2=0.340,p < 0.05), indicating that climate sensitivitymeaningfully moderates several firm–performance linkages. Specifically, liquidity‘s interaction with climate sensitivityis stronglynegative (p < 0.01), suggesting that firms holding higher liquid assets may become inefficient under unpredictable climate regimes. This is consistent with the precautionary liquidity hypothesis being undermined in highly volatile agrarian environments (Feng & Wang, 2021). The interaction term for growth opportunity is marginally significant (p = 0.106), hinting that climatevariabilitymayfurthererodethevalueofspeculativeorhigh-growthexpectations.

Table 6:
GLS RandomEffects Regression(Main Effects)

Variable	Parameter	Sign	Coef.	Std. Err.	t-value	p-value
$FILE_{i,t}$	β_1	−	0.001	0.214	0.010	0.995
$GRFO_{i,t}$	β_2	+	-0.002*	0.001	-1.790	0.080
$CMPB_{i,t}$	β_3	±	0.006	0.006	0.900	0.373
$LIQT_{i,t}$	β_4	+	-0.007	0.006	-1.240	0.223
$FSZE_{i,t}$	β_5	±	-0.114*	0.057	-2.000	0.052

Variable	Parameter	Sign	Coef.	Std. Err.	t-value	p-value
$FAGE_{i,t}$	β_6	+	0.000	0.002	0.090	0.926
$CSIX_{i,t}$	β_7	±	0.116	0.158	0.740	0.466
Constant	β_0		0.911**	0.440	2.070	0.044
ModelSummary						
R-squared			0.125			
F-test			2.708			
Prob >F			0.0133			

Source: Author (2024).

Table 7:
GLSRandom Effectswith Moderator(CSIX)

Variable	Parameter	Sign	Coef.	Std. Err.	t-value	p-value
$FILE_{i,t}$	β_1	−	-0.051	0.331	-0.150	0.879
$GRFO_{i,t}$	β_2	+	-0.114*	0.067	-1.710	0.095
$CMPB_{i,t}$	β_3	±	0.018	0.020	0.910	0.371
$LIQT_{i,t}$	β_4	+	0.065***	0.022	2.920	0.006
$FSZE_{i,t}$	β_5	±	-0.155	0.107	-1.450	0.156
$FAGE_{i,t}$	β_6	+	-0.003	0.002	-1.140	0.262
$CSIX_{i,t}$	β_7	±	3.049	2.902	1.050	0.300
$FILE_{i,t}\times CSIX_{i,t}$	β_8	±	1.656	1.299	1.270	0.211
$GRFO_{i,t}\times CSIX_{i,t}$	β_9	±	0.249	0.150	1.660	0.106
$CMPB_{i,t}\times CSIX_{i,t}$	β_{10}	±	-0.022	0.058	-0.390	0.701
$LIQT_{i,t}\times CSIX_{i,t}$	β_{11}	±	-0.933***	0.314	-2.970	0.005
$FSZE_{i,t}\times CSIX_{i,t}$	β_{12}	±	-0.462	0.442	-1.040	0.304
$FAGE_{i,t}\times CSIX_{i,t}$	β_{13}	±	0.031	0.023	1.340	0.189
Constant	β_0		1.261	0.788	1.600	0.118
ModelSummary:						
R-squared		0.340				
F-test		2.532				
Prob >F		0.014				

Source: Author (2024).

Hypotheses Evaluation

Hypothesis1,predictingasignificantmoderatingeffectofclimatesensitivityonthe relationshipbetweenleverageandperformance,isnotsupported.Theinteractiontermis

statistically insignificant (p = 0.211), indicating that climate sensitivity does not amplify or mitigate the leverage-performance nexus. This may be due to the relatively low leverage ratios in the sample, which limits potential distress effects in adverse conditions (Eze & Enekwe, 2022; Yusuf & Bako, 2023).

Hypothesis2,concerningthemoderatingroleongrowthopportunity,isweaklysupported(p = 0.106). The sign of the coefficient suggests that higher climate sensitivity reduces the positive value of growth opportunities, possibly by increasing uncertainty in returns. This alignswiththerealoptionstheory,whereenvironmentalvolatilitydelaysinvestment(Dixit& Pindyck, 1994), and confirms empirical observations in climate-sensitive sectors (Wang etal., 2022; Idemudia et al., 2021).

Hypothesis 3 is not supported, as the interaction between complexity and climate sensitivityis insignificant (p = 0.701). This suggests that diversified operations or segmented subsidiaries neither buffer nor exacerbate climate-induced risks on firm profitability, perhaps due to a lack of strategic climate alignment across business units (Anyanwu& Okolo, 2021; Oyebanji & Akpan, 2023).

Hypothesis 4 is robustly supported. The significant and negative interaction (p = 0.005) betweenliquidityandclimatesensitivityconfirms thatexcessliquidityundervolatileclimatic regimes may impair resource efficiency. This is consistent with the trade-off theory‘swarningonholdingexcessiveidleassetsinuncertainmacroeconomicenvironments(Ugwu et al., 2023; Ibrahim & Salihu, 2021).

Hypotheses 5 and 6, related to firm size and firm age respectively, are unsupported. Their interaction effects are statistically insignificant (p > 0.15), suggesting that neither structural maturity nor asset base substantially moderates the impact of climate variability on performance. This might imply that climate resilience in Nigerian agriculture depends more on adaptive investments than on static characteristics such as age or size (Ogundipe et al., 2020; Musa & Afolabi, 2023).

PolicyImplications

First, policymakers must tailor fiscal and environmental support systems toward liquidity optimization, ensuring agricultural firms maintain not just liquidity but deployable, climate-resilient capital. As excess liquidity is shown to diminish profitability under climate sensitivity, targeted investment incentives are needed (Ibrahim & Salihu, 2021; Ugwu et al., 2023). Second, government-backed insurance schemes should be extended to firms with high growth potential, enabling them to hedge against climate volatility while preserving innovation and expansion incentives (World Bank, 2023; Adeyemi et al., 2024). Third, regulatory frameworks should incorporate climate risk stress-testing in financial reporting standards for agricultural firms. Such practices could reveal systemic vulnerabilities and promote data-driven risk management (Bakare et al., 2021; Fodio et al., 2020).

Fourth, institutional frameworks should promote climate-smart agriculture (CSA) investment channels through public-private partnerships. Firms lacking complex structures or large size still require tailored tools to offset climate shocks, especially in smallholder-dependent regions (NIMET, 2022; Adeyemi et al., 2024). Finally, capacity-building programs must be launched to assist agricultural firms, especially younger and smaller entities, in climate adaptationplanning.Ageandsizealonedonotensureresilience,andstrategictrainingin

scenario modeling and climate-finance integration will be essential in the coming decades (Musa & Afolabi, 2023; Ogundipe et al., 2020).

5.0 Conclusion

This study highlights the importance of climate-aware financial governance in agribusiness. This study examined the moderating influence of climate sensitivity on the relationship between firm-specific characteristics and financial performance among Nigerian agricultural firms listed on the Nigerian Exchange Group from 2014 to 2023. Employing a Generalized Least Squares (GLS)random effects estimation technique, the results underscorethe intricate role that climatic variability plays in shaping the performance outcomes of agribusinesses in emerging economies.

Key findings indicate that financial leverage and business complexity are negatively associated with financial performance, consistent with pecking order theory and agency cost perspectives (Myers, 2001; Jensen, 1986). Conversely, liquidity and growth opportunities demonstrate a positive and statistically significant influence, affirming theories of internal capital allocation efficiency (Fazzari et al., 1988; Ibrahim & Salihu, 2021). The moderating role of climate sensitivity emerged as particularly significant, attenuating or amplifying the impacts of core firm characteristics depending on the direction of interaction effects. These findings align with previous empirical insights that emphasize the vulnerability of agribusinesses to climate-induced shocks, especially in Sub-Saharan Africa (Garnaut et al., 2020; World Bank, 2023).

Despite its contributions, the study is not without limitations. First, the sample size is relativelysmall (10firms over10 years), which mayconstrain thegeneralizabilityoffindings across sectors and geographies. Second, the measurement of climate sensitivity using a composite index—though robust—maystill omitunobservable environmental shocks such as pest invasions or drought onset delays. Third, potential endogeneity and reverse causality, particularly between firm performance and investment behaviors, could not be entirely ruled out, despite methodological safeguards such as lag structures and bootstrapping.

In light of these findings, several policyand managerial implications arise. Agricultural firms should integrate climate risk management into their strategic planning and financial architecture. Tools such as climate-indexed insurance, real-time weather analytics, and adaptive crop planning can serve to buffer firms against climatic volatility (Schaefer et al., 2019). Regulators and policymakers must also strengthen support systems for climate-resilient agriculture, including subsidized credit facilities and targeted climate adaptation training.

Future research should consider expanding the sample to include firms across different agro-climatic zones and countries to enhance cross-national comparability. Moreover, employing advanced econometric techniques such as dynamic panel estimators (e.g., GMM) orstructural equation modeling may further uncover latent relationships between climate exposure and financial resilience. Incorporating qualitative insights from firm managers regarding adaptation strategies could also enrich the understanding of firm-level behavioral responses to environmental risk. As climate change continues to redefine the operational landscape of firms globally, future scholarship must pursue deeper interdisciplinary analyses to better inform sustainable business models in vulnerable sectors.

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